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PATENT

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Applicant: Hiroshi Kushitani et al. : Art Unit:
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FOR: SAW FILTER AND ELECTRONIC DEVICE INCLUDING SAW FILTER

VERIFICATION OF A TRANSLATION

Assistant Commissioner for Patents
Washington, D.C. 20231
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1. My name and post office address are as stated below.

2. That I am knowledgeable in the English language and in the language of JP2002-228868, and I believe the attached English translation to be a true and complete translation of JP2002-228868.

3. The document for which the attached English translation is being submitted is a patent application on an invention entitled SAW FILTER AND ELECTRONIC DEVICE INCLUDING SAW FILTER.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and

belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Date: October 21, 2004

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[NAME OF ARTICLE] Specification 1

[NAME OF ARTICLE] Drawing 1

[NAME OF ARTICLE] Abstract 1

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[Name of the Document] Specification

[Title of the Invention] Surface acoustic wave (SAW) filter and electronic device using the same

[Claims]

[Claim 1] A SAW filter comprising:

a series resonator provided between an input terminal and an output terminal;

a first and a second parallel resonators provided between a first and a second grounding electrodes before and after this series resonator;

a first and a second inductance elements interposed among the first, second and third grounding electrodes respectively; and

a third inductance element provided between the third grounding electrode and a grounding terminal;

wherein

a capacitance element is interposed between the first and the second grounding electrodes.

[Claim 2] A SAW filter as defined in Claim 1, wherein the capacitance element is formed with grounding electrodes facing each other on a piezoelectric substrate.

[Claim 3] A SAW filter as defined in Claim 1, wherein the capacitance element is formed by putting the first and second grounding electrodes face to face on a piezoelectric substrate.

[Claim 4] A SAW filter as defined in Claim 3, wherein the capacitance element is formed with projecting electrodes protruding toward each other from between the first and second grounding electrodes on the piezoelectric

substrate.

[Claim 5] A SAW filter as defined in Claim 4, wherein the projecting electrodes are interdigital electrodes.

[Claim 6] An electronic device realized by combining a SAW filter as defined in either one of Claims 1 to 5 with other electronic element.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a SAW filter and an electronic device using the same used for various types of communication apparatus, for example.

[0002]

[Background Art]

As conventional SAW filter of this type, there is one called ladder type as shown in Fig. 9. This ladder type SAW filter as it is generally called is constructed, as shown in Fig. 9, by connecting series resonators 3, 4, 5 between input terminal 1 and output terminal 2, connecting parallel resonators 6, 7 before and after series resonator 4, connecting inductance elements 8, 9 to parallel resonators 6, 7, connecting inductance element 10 to them at an end, and connecting the other end of inductance element 10 to grounding terminal 11.

[0003]

The characteristic profile of a conventional ladder type SAW filter constructed as above is as shown with line B in Fig. 4. As shown by this line B, the pass band is rather wide and attenuation profiles are seen on

both sides of the pass band.

[0004]

[Problems to be Solved by the Invention]

While the conventional ladder type SAW filter described above is widely used and highly evaluated currently, it also has a problem to be further improved. That is, no sufficient attenuation amount is secured on the lower side of the pass band, as shown with line B in Fig. 4. Namely, there is a tendency that the attenuation amount once drops on the lower side of the pass band and rises again after that. Further attenuating this portion which once drops on the lower side of the pass band and rises again leads to further improvement of the characteristic profile of the filter.

[0005]

The objective of the present invention is therefore to improve the characteristic profile of the filter.

[0006]

[Means to Solve the Problems]

The invention indicated in Claim 1 of the present invention is a SAW filter comprising:

a series resonator provided between an input terminal and an output terminal;

a first and a second parallel resonators provided between a first and a second grounding electrodes before and after this series resonator;

a first and a second inductance elements interposed among the first, second and third grounding electrodes respectively; and

a third inductance element provided between the third grounding

electrode and a grounding terminal;

wherein

a capacitance element is interposed between the first and the second grounding electrodes.

[0007]

Namely, by interposing a capacitance element between the first and the second grounding electrodes, a parallel element is formed as electrical equivalent circuit for the third inductance element provided between the third grounding electrode and the grounding terminal and, by forming this parallel element, it becomes possible to eventually secure a large attenuation on the lower side of the pass band as shown with line A in Fig. 4. This enables to improve the characteristic profile of the filter.

[0008]

The invention indicated in Claim 2 is a SAW filter as defined in Claim 1, wherein the capacitance element is formed with grounding electrodes facing each other on a piezoelectric substrate. According to this construction, it becomes possible to make a SAW filter of simple construction, because there is no need of providing any other element of such type.

[0009] The invention indicated in Claim 3 is a SAW filter as defined in Claim 1, wherein the capacitance element is formed by putting the first and second grounding electrodes face to face on a piezoelectric substrate. The formation of the capacitance element can be made most easily if it is constructed by putting the first and second grounding electrodes face to face on a piezoelectric substrate.

[0010]

The invention indicated in Claim 4 is a SAW filter as defined in Claim 3, wherein the capacitance element is formed with projecting electrodes protruding toward each other from between the first and second grounding electrodes on the piezoelectric substrate. By adopting this construction, it becomes possible to secure a larger surface area and a larger capacity of capacitance element, compared with a construction in which straight lines face each other.

[0011]

The invention indicated in Claim 5 is a SAW filter as defined in Claim 4, wherein the projecting electrodes are interdigital electrodes. A larger capacity can be obtained with the adoption of interdigital projecting electrodes.

[0012]

The invention indicated in Claim 6 is an electronic device realized by combining a SAW filter as defined in either one of Claims 1 to 5 with other electronic element. A large attenuation secured on the lower side of the pass band of the SAW filter owned by the electronic device helps to improve the characteristic profile of the filter.

[0013]

[Preferred embodiment of the invention]

A preferred embodiment of the invention will be explained below with reference to drawings.

[0014]

(Preferred embodiment 1)

Fig. 1 indicates a preferred embodiment of the present invention. In Fig. 1, reference numeral 12 is an input terminal and, between this input terminal 12 and output terminal 13 are connected series resonators 14, 15, 16 in series from input terminal 12 side toward input terminal 13. Moreover, before and after the series resonator 15 are connected one end of parallel resonators 17, 18, and the other end of those parallel resonators 17, 18 are connected to first grounding electrode 19 and second grounding electrode 20 respectively. Furthermore, between first grounding electrode 19 and third grounding electrode 21 is connected first inductance element 22, and between second grounding electrode 20 and third grounding electrode 21 is connected second inductance element 23 respectively.

[0015]

Still more, between third grounding electrode 21 and grounding terminal 24 is connected third inductance element 25. And the most important thing in the above-described construction is that a capacitance element 26 is connected between first grounding electrode 19 and second grounding electrode 20, namely capacitance element 26 is interposed between grounding electrode 19 and second grounding electrode 20.

[0016]

In the above-described construction, the characteristic profile of the filter indicates band-pass characteristics with little loss from 2.11 GHz to 2.17 GHz as shown with line A in Fig. 4, and a large amount of attenuation can be secured on both sides of this range. Especially, it is the largest characteristic that, in this preferred embodiment, a large attenuation is secured over a wider range compared with a conventional example as shown

with line B in Fig. 4, on the lower side of the pass band. The reason why such large attenuation can be secured may be explained with Fig. 3 and Fig. 5.

[0017]

Fig. 3 shows a packaged SAW filter as it is generally called, and indicates that first inductance element 22 and second inductance element 23 are formed with wires, and also indicates that third inductance element 25 is formed with an electrode pattern formed on the package.

[0018]

Fig. 5 indicates a circuit which has been submitted to equivalent circuit conversion about the first electric circuit in this preferred embodiment.

[0019]

The attenuation on the lower side of the pass band of the SAW filter owes much to first, second and third inductance elements 22, 23, 25, and conventionally the attenuation characteristics used to be designed by adjusting those inductances. However, those inductances are about determined by the shape of the package as shown in Fig. 3, and the conventional SAW filter had attenuation characteristics of rising again after once dropping on the lower side of the pass band as shown with line B in Fig. 4.

[0020]

In Fig. 1, first, second and third inductance elements 22, 23, 25 form a Y-shaped circuit among first grounding electrode 19, second grounding electrode 20 and grounding terminal 24. This Y-shaped circuit is converted,

by electric equivalent circuit conversion, into a fourth inductance element 27 connected between first grounding electrode 19 and second grounding electrode 20, a fifth inductance element 28 connected between first grounding electrode 19 and grounding terminal 30, and inductance element 29 connected between second grounding electrode 20 and grounding terminal 31, as shown in Fig. 5.

[0021]

At that time, if the inductances of first, second, third, fourth, fifth and sixth inductance elements 22, 23, 25, 27, 28, 29 are put as L_1, L_2, L_3, L_4, L_5, L_6 respectively, the following relation (Formula 1) is established among them:

[0022]

[Formula 1]

$$L_4 = \frac{L_1 L_2 + L_2 L_3 + L_3 L_1}{L_3}$$

$$L_5 = \frac{L_1 L_2 + L_2 L_3 + L_3 L_1}{L_2}$$

$$L_6 = \frac{L_1 L_2 + L_2 L_3 + L_3 L_1}{L_1}$$

[0023]

Generally L_3 is much smaller compared with L_1 and L_2 and, therefore, while L_5 becomes an inductance almost identical with L_1 and L_6 becomes an inductance almost identical with L_2 as one can see from (Formula 1), L_4 becomes a very large inductance.

[0024]

In such description, capacitance element 26 gets in a state connected in parallel to inductance element 27, and it becomes possible to greatly change the impedance characteristics of inductance element 27 with the capacity of capacitance element 26. As a result, the attenuation characteristics on the lower side of the pass band can be adjusted, with no change in the design of series resonators 14, 15, 16 and parallel resonators 17, 18.

[0025]

As explained above, by simply adopting such construction, it becomes possible to obtain an extremely large attenuation on the lower side of the pass band, as shown with line A in Fig. 4.

[0026]

Moreover, because L_4 becomes an extremely large inductance as mentioned above, the capacity of capacitance element 26 can take a very small value. Therefore, capacitance element 26 can be prepared in the same way as series resonators 14, 15, 16 and parallel resonators 17, 18. The method for it will be explained below.

[0027]

Fig. 2 indicates series resonators 14, 15, 16 and parallel resonators 17, 18 for concretely constructing Fig. 1. As one may see from this figure, capacitance element 26 can be formed as interdigital type in which part of first and second grounding electrodes 19, 20 protrudes mutually toward the other.

[0028]

Fig. 6, Fig. 7, Fig. 8 indicate other preferred embodiments. In those preferred embodiments, the aforementioned electrodes for capacitance

element 26 to be protruded mutually toward each other from first grounding electrode 19 and second grounding electrode 20 are realized as electrodes 26a simply protruding on the long side in the case of Fig. 6, electrodes 26b in L shape once protruding straight and then facing each other on their long sides in the case of Fig. 7, and electrodes 26c with ups and downs in the case of Fig. 8, and are made to face each as shown in Fig. 6 to Fig. 8 respectively.

[0029]

[Advantages of the Invention]

As described above, the present invention is realized by comprising:

a series resonator provided between an input terminal and an output terminal;

a first and a second parallel resonators provided between a first and a second grounding electrodes before and after this series resonator;

a first and a second inductance elements interposed among the first, second and third grounding electrodes respectively; and

a third inductance element provided between the third grounding electrode and a grounding terminal;

wherein

a capacitance element is interposed between the first and the second grounding electrodes.

[0030]

Namely, by interposing a capacitance element between the first and the second grounding electrodes, a parallel element is formed as electrical equivalent circuit for the third inductance element provided between the third grounding electrode and the grounding terminal and, by forming this

third grounding electrode and the grounding terminal and, by forming this parallel element, it becomes possible to eventually secure a large attenuation amount on the lower side of the pass band as shown with line A in Fig. 4. This enables to improve the characteristic profile of the filter.

[Brief Description of the Drawings]

Fig. 1 is a circuit diagram showing a preferred embodiment of the present invention.

Fig. 2 is a plan view showing the electrode pattern in a preferred embodiment of the present invention.

Fig. 3 is a sectional view showing the package portion in a preferred embodiment of the present invention.

Fig. 4 is a frequency characteristics chart of a preferred embodiment of the present invention.

Fig. 5 is a circuit diagram showing electrical equivalent circuit conversion in a preferred embodiment of the present invention.

Fig. 6 is a plan view showing the electrode pattern in other preferred embodiment of the present invention.

Fig. 7 is a plan view showing the electrode pattern in other preferred embodiment of the present invention.

Fig. 8 is a plan view showing the electrode pattern in other preferred embodiment of the present invention.

Fig. 9 is a circuit diagram showing a conventional example.

[Description of the Reference Numerals and Signs]

10, 27, 28, 29	Inductance element
12	Input terminal

13	Output terminal
14, 15, 16	Series resonator
17, 18	Parallel resonator
19	First grounding electrode
20	Second grounding electrode
21	Third grounding electrode
22	First inductance element
23	Second inductance element
24, 30, 31	Grounding terminal
25	Third inductance element
26	Capacitance element

[Name of the Document] Abstract

[Abstract]

[Object] The objective of the present invention is to enhance the filter characteristic profile of SAW filter.

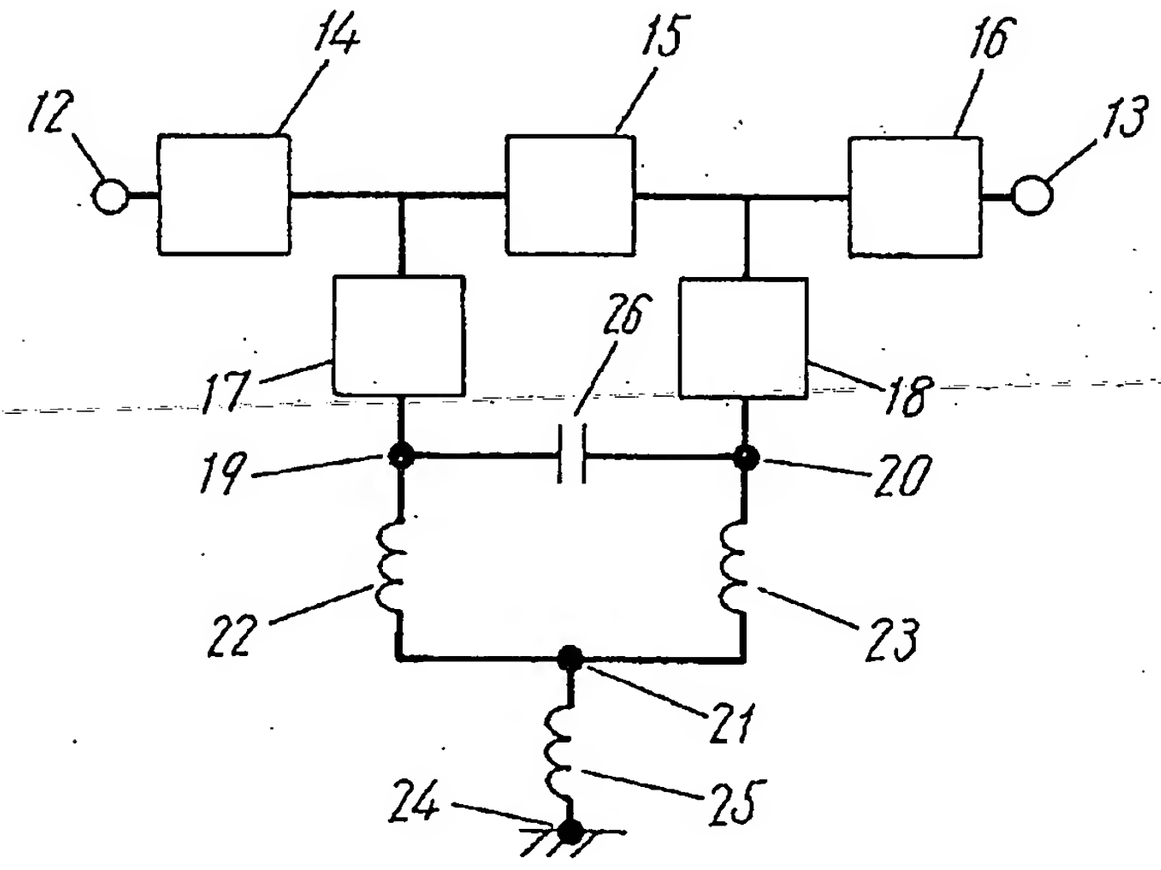
[Means to Solve the Problems] To achieve said objective, the present invention is realized by connecting a capacitance element 26 between first grounding and second grounding electrodes 19, 20 to which are connected first and second parallel resonators 17, 18 provided before and after the series resonator 15.

[Selected Drawing] Fig. 1

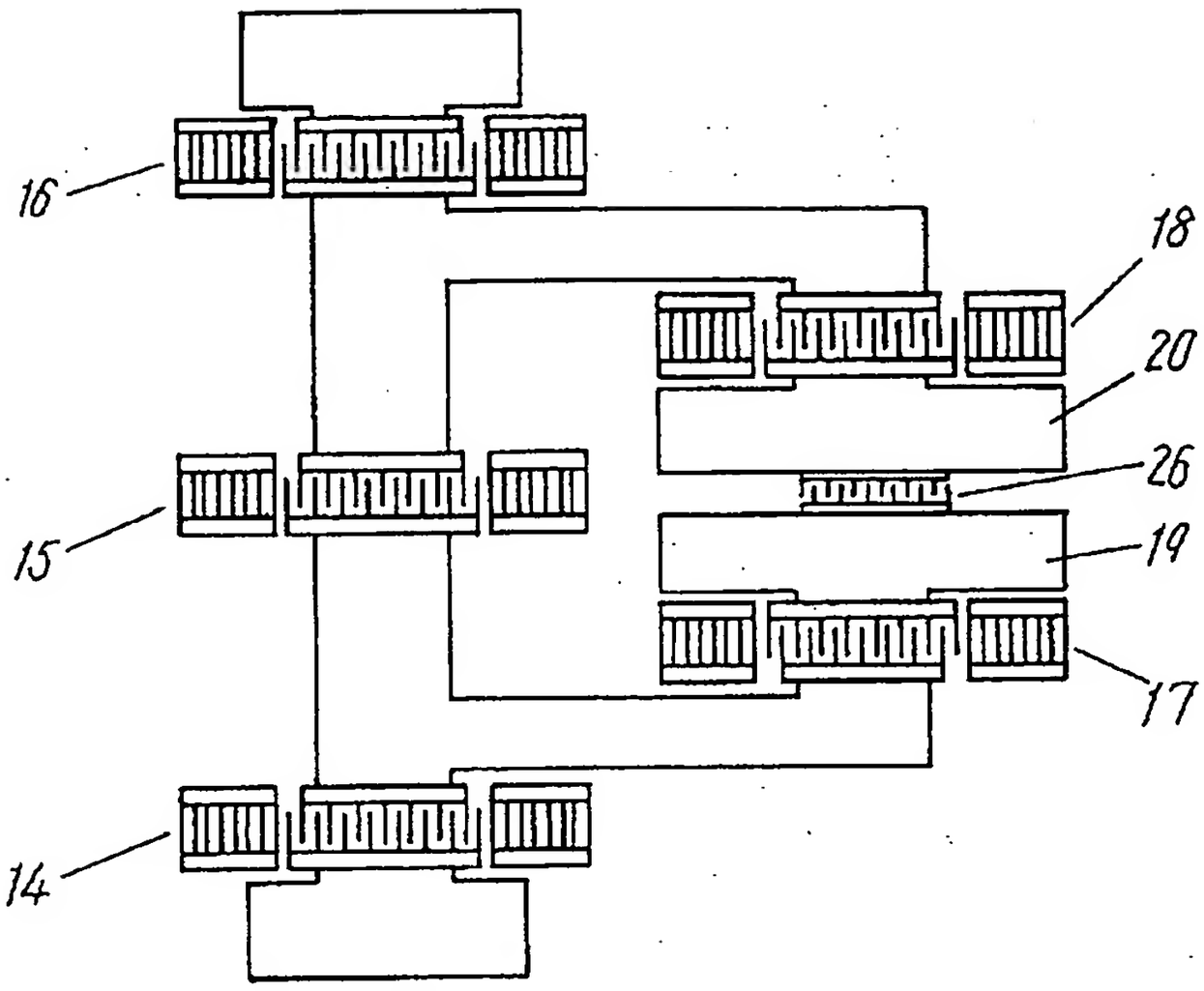
[Name of the Document] Drawing

[Fig. 1]

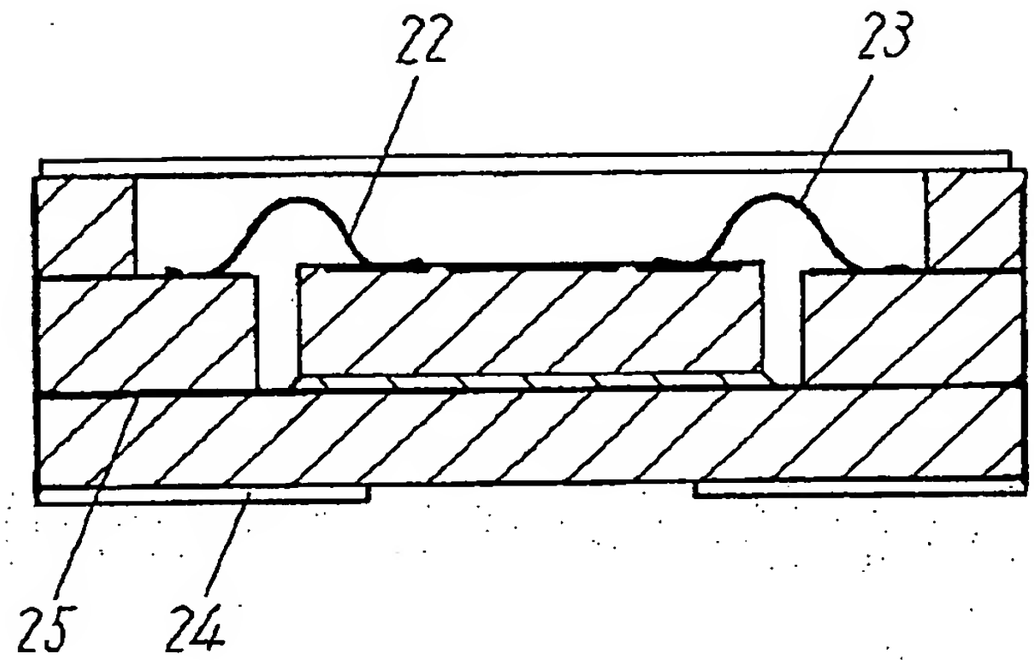
12	Input terminal	21	Third grounding electrode
13	Output terminal	22	First inductance element
14-16	Series resonator	23	Second inductance element
17, 18	Parallel resonator	24	Grounding terminal
19	First grounding electrode	25	Third inductance element
20	Second grounding electrode	26	Capacitance element



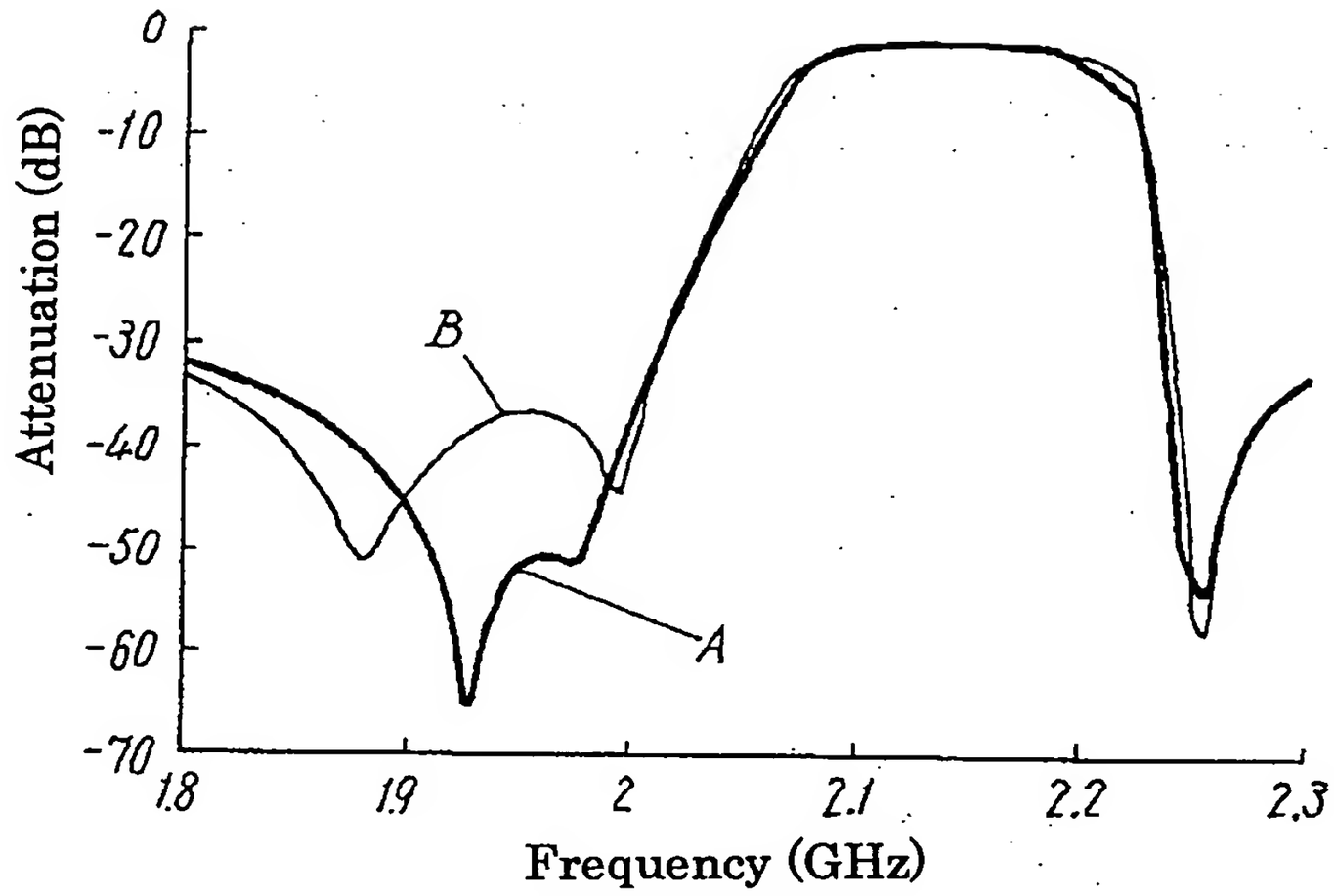
[Fig. 2]



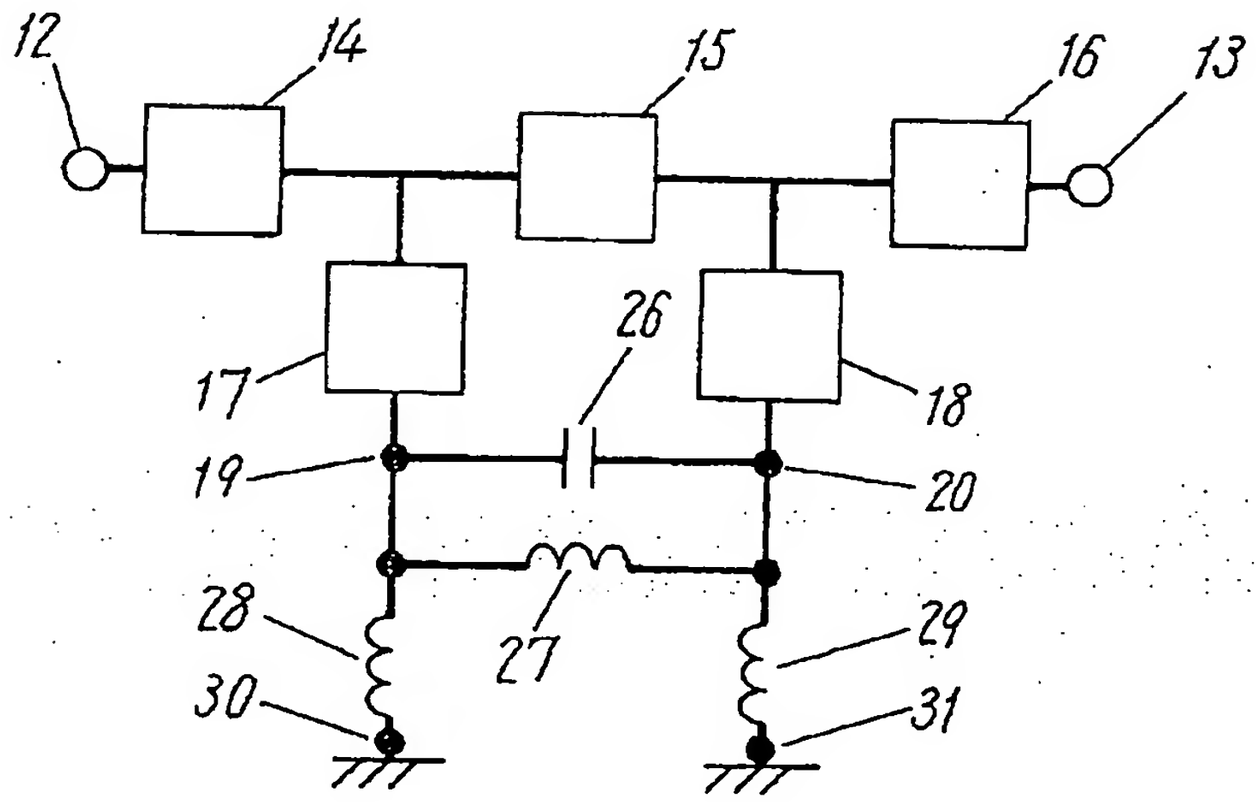
[Fig. 3]



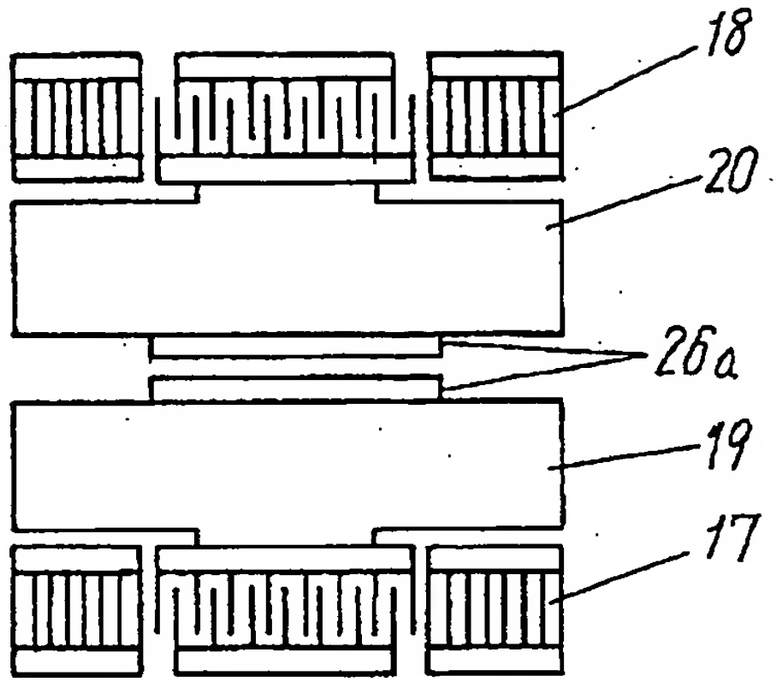
[Fig. 4]


0
-10
-20
-30
-40
-50
-60
-70
Attenuation (dB)
B
A
1.8
1.9
2
2.1
2.2
2.3
Frequency (GHz)

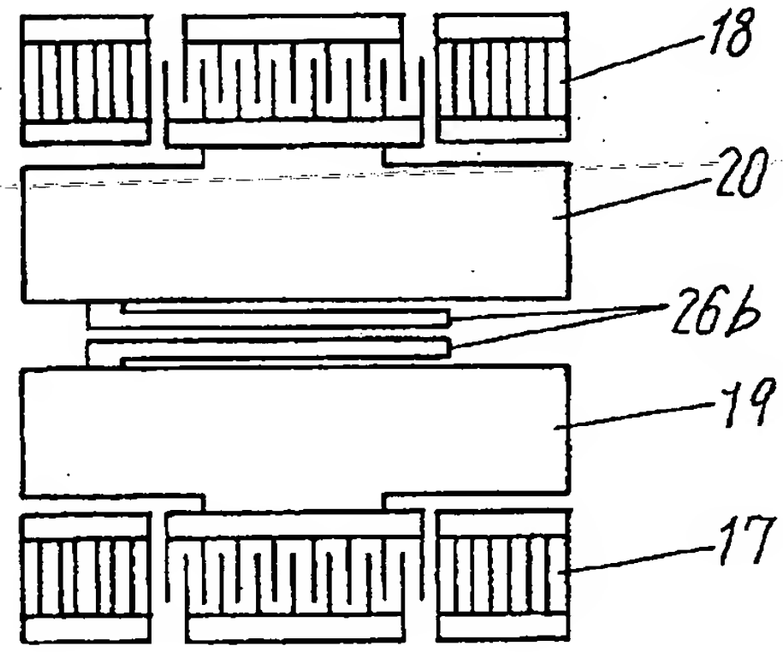
[Fig. 5]


12
14
15
16
13
17
26
18
19
20
28
27
29
30
31

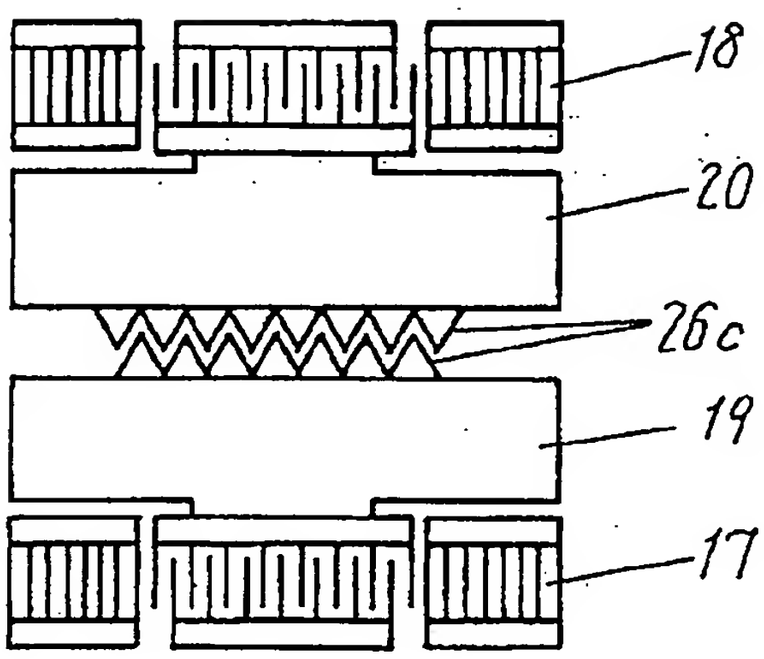
[Fig. 6]



[Fig. 7]



[Fig. 8]



[Fig. 9]